Annals of Clinical and Analytical Medicine
Original Research

Evaluation of scoring methods in trauma patients with rib fractures

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Abstract
Aim: In thoracic traumas, it is very important to provide accurate treatment after determining the severity of the trauma. Therefore, scoring systems are used to determine morbidity and mortality rates. These scoring methods include the Rib Fracture Score (RFS), Chest Wall Injury Score (CWIS), Chest Trauma Score (CTS), Thoracic Trauma Severity Score (TTSS), and Injury Severity Score (ISS). In our study, we aimed to evaluate the scoring systems in patients with post-traumatic rib fractures and accompanying pathologies, and to determine the trauma severity, mortality and morbidity rates with these scorings.
Material and Methods: The records of 482 patients followed up and treated for post-traumatic rib fractures. The patients were divided into two groups as survivors (n: 418) and those who died (n: 64). The mean number of fractures, RFS, CWIS, CTS, TTSS, ISS values, and mortality and morbidity rates were recorded.
Results: The mean number of fractures was 3.02±2.92, RFS; 4.84±4.71, CWIS; 1.68±0.79, CTS; 5.01±1.46, TTSS; 6.58±2.20, ISS; 7.90±8.64. When surviving and deceased patients were compared in terms of the mean number of fractures, RFS, CWIS, CIS, TTS, and ISS, the number of deceased patients was statistically significant compared to the surviving patients ($p<0.05$).
Discussion: It was observed that mortality rates increased in trauma patients as the number of rib fractures increased with concomitant pathologies such as pneumomediastinum, hemothorax, pneumothorax, contusion, and flail chest as well as concomitant organ injuries such as spleen, kidney and liver. These pathologies and the presence of concomitant injuries were significant in mortality and morbidity.

Keywords
Fractures, Ribs, Scoring, Trauma

DOI: 10.4328/ACAM.21197 Received: 2022-04-18 Accepted: 2022-06-17 Published Online: 2022-06-18 Printed: 2022-09-01 Ann Clin Anal Med 2022;13(9):1022-1025
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Introduction

The rate of rib fractures in thoracic traumas is 35-40% [1]. Due to fractures, pneumothorax and hemothorax may develop in the early period, while atelectasis and pneumonia may occur in the late period. The number of fractures, respiratory distress, and concomitant organ injuries cause serious problems [2].

In thoracic traumas, it is very important to provide accurate treatment after determining the severity of the trauma, to predict complications and the need for intensive care, and to explain the prognosis. In these patients, if the assessment of trauma severity is done correctly, the implementation and follow-up of treatment protocols will become more accurate. Therefore, scoring systems are used to determine morbidity and mortality rates [3]. These scoring methods include the Rib Fracture Score (RFS), Chest Wall Injury Score (CWIS), Chest Trauma Score (CTS), Thoracic Trauma Severity Score (TTSS), and Injury Severity Score (ISS) [4].

In our study, we aimed to evaluate the scoring systems in patients with post-traumatic rib fractures and accompanying pathologies, and to determine the trauma severity, mortality and morbidity rates with these scorings.

Material and Methods

Patients

The records of 482 patients who were followed up and treated for post-traumatic rib fractures between 2015 and 2021 were evaluated.

Procedures

The patients were divided into two groups as surviving (n: 418, 87%) and deceased patients (n: 64, 13%), regardless of the number of fractures. Age, gender, symptoms, localization of fractures, radiological findings, diagnosis and treatment methods, complications, concomitant injuries, mean number of fractures, RFS, CWIS, CTS, TTSS, ISS values, and mortality and morbidity rates were recorded.

Statistics

IBM SPSS Statistics version 22.0 was used for data analysis. Continuous variables were expressed as mean±standard deviation, while categorical variables as number-ratio. Results were evaluated with the Kruskal-Wallis test, analysis of variance and the Mann-Whitney-U tests. $p<0.05$ was considered significant.

Results

The total number of patients was 482, and the mean age was 55.2±18.17 years. Etiological causes were traffic accidents in 286 (59%), falling from a height in 153 (32%), and assault in 42 (9%). There were 445 males and 37 females among the patients. In 221 of the patients, the fractures were on the right, 226 had fractures on the left, and 35 had bilateral fractures (Table 1).

Concomitant pathologies were contusion in 45, pneumothorax in 34, hemothorax in 29, flail chest in 13, and pneumomediastinum in 7. Concomitant injuries were sternum in 34, clavicle in 20, scapula in 13, vertebra in 12, vertebra+scapula in 9, liver in 5, liver+kidney in 2, kidney in 1, spleen+kidney in 1, and liver+kidney+spleen in 1 (Table 2). The mean number of fractures was 3.02±2.92, RFS; 4.84±4.71, CWIS; 1.68±0.79, CTS; 5.01±1.46, TTSS; 6.58±2.20, ISS; 7.90±8.64.

The mean age of the surviving patients was 56.01±17.98; 384 were male while 34 were female; 199 had right-sided localization, 200 had left-sided localization, and 19 had bilateral localization. Contusion was found in 31, pneumothorax in 26, hemothorax in 16, flail chest in 5 and pneumomediastinum in 3 patients. As concomitant injuries, 27 had sternum fracture, 11 had scapula, 17 had clavicle, 10 had vertebrae, 7 had vertebra+scapula, 1 had kidney injury, 4 had liver injury, and 1 had liver+kidney injury. The mean number of fractures was 2.78±2.58, RFS; 4.27±3.58, CWIS; 1.60±0.70, CTS; 4.87±1.39, TTSS; 6.32±1.99, ISS; 6.98±8.04 (Tables 1,2,3).

The mean age of the deceased patients was 60.10±19.16 years; 61 were male, while 3 were female. Fractures were on the right side in 22, on the left side in 26, and bilateral in 16.

Table 1. Demographic distribution of patients with rib fractures

Variables	Total	Surviving group	Deceased group
Male	445, 92%	384, 92%	61, 95%
Female	37, 8%	34, 8%	3, 5%
Right hemithorax	221, 46%	199, 48%	22, 34%
Left hemithorax	226, 47%	200, 48%	26, 41%
Bilateral	35, 7%	19, 4%	16, 25%

%; Percentage

Table 2. Concomitant pathologies accompanying rib fractures

Concomitant pathology	Total	Survivng group	Deceased group
Pneumomediastinum	7, 5%	3, 1%	4, 6%
Hemothorax	29, 23%	16, 4%	13, 20%
Pneumothorax	34, 27%	26, 6%	8, 12%
Contusion	45, 35%	31, 7%	14, 22%
Flail chest	13, 10%	5, 1%	8, 12%
Clavicle fracture	20, 4%	17, 4%	3, 5%
Scapula fracture	13, 3%	11, 3%	2, 3%
Sternum fracture	34, 7%	27, 6%	7, 11%
Vertebra fracture	12, 2%	10, 2%	2, 3%
Vertebra + scapula fracture	9, 2%	7, 2%	2 3%
Kidney ınjury	1, 0.2%	10.23%	0
Spleen + kidney injury	1, 0.2%	0	1, 2%
Liver injury	5, 1%	4, 1%	1, 2%
Liver + kidney injury	2, 0.4%	1, 0.23%	1, 2%
Liver + kidney + spleen injury	1, 0.2%	0	1, 2%

%; Percentage

Table 3. Comparison of the mean score values of the groups (between survivors and deceased)

Average scores	Surviving patients	Deceased patients	The z-score	p-value
Average RF	2,78 ± 2,58	4,62 ± 4,24	-352.134	0.00044
Average RFS	4,27 ± 3,58	8,54 ± 8,30	-463.151	0.00001
Average CWIS	1,60 ± 0,70	2,20 ± 1,12	-382.008	0.00014
Average CTS	4,87 ± 1,39	5,93 ± 1,59	-478.377	0.00001
Average TTSS	6,32 ± 1,99	8,34 ± 2,68	-553.979	0.00001
Average ISS	6,98 ± 8,04	13,89 ± 0,03	-472.643	0.00001

RF; Rib fracture, RFS; Rib Fracture Score, CWIS; Chest Wall Injury Score, CTS; Chest Trauma Score, TTSS; Thoracic Trauma Severity Score, ISS; Injury Severity Score

Contusion was detected in 14, pneumothorax in 8, hemothorax in 13, flail chest in 8 and pneumomediastinum in 4 patients. As concomitant injuries, 7 had sternum fracture, 2 scapula, 3 clavicle, 2 vertebra, 2 vertebra+scapula, 1 spleen+kidney, 1 liver, 1 liver+kidney, 1 liver+kidney+spleen injury. The mean number of fractures: 4.62±4.24, RFS; 8.54±8.30, CWIS; 2.20±1.12, CTS; 5.93±1.59, TTSS; 8.34±2.68, ISS; 13.89±10.03 (Tables 1, 2, 3).

When comparing survivors and deceased patients in terms of mean number of fractures, RFS, CWIS, CIS, TTS, and ISS, the number of deceased patients was statistically significant compared to the surviving patients ($p<0.05$). It was observed that mortality rates increased in trauma patients as the number of rib fractures increased with concomitant pathologies such as pneumomediastinum, hemothorax, pneumothorax, contusion, and flail chest as well as concomitant organ injuries such as spleen, kidney and liver. These pathologies and the presence of concomitant injuries were significant in mortality and morbidity. In the treatment, 60 (12%) patients underwent tube thoracostomy, 10 (2%) underwent thoracotomy (7 bleeding control+hematoma evacuation, 3 primary diaphragmatic repair), 2 (0.41%) underwent chest wall reconstruction. Additionally, 10 (2%) of the flail chest patients were followed in the intensive care unit, and 3 (1%) had fixation+intensive care follow-up. Finally, fiberoptic bronchoscopy+esophageal passage graphy and endoscopy were performed in all patients with pneumomediastinum.

The most common morbidities in patients were wound infection (n: 103, 21%), pneumonia (n: 42, 9%), and atelectasis (n: 52, 11%). The mean length of stay was 7±5 days.

Discussion

The incidence of rib fractures due to trauma has been reported to be 7-9%, and the mortality rate to be 10-12% [5, 6]. Karadayi et al. reported that the mean age was 51.50 (17-96) in 214 patients with rib fractures, 75.7% were over 65 years old, while 24.3% were under 65 years old; 52 of the patients had isolated fractures, 53 had 2, and 111 had more than 2 rib fractures, and there was a correlation between the increased number of broken ribs and mortality and morbidity [7]. In our study, the mean age of patients was 55.2±18.17 years, and the mortality rate was 13%.

Early complications in rib fractures are contusion, pneumothorax, and hemothorax, while late complications are atelectasis and pneumonia. Broken rib ends may lacerate the intercostal muscles and rupture the internal mammary and intercostal arteries, resulting in massive hemothorax. Fracture ends can puncture the lung, diaphragm, and abdominal organs [8, 9]. In our study, 45 patients had contusion, 34 pneumothorax, 29 hemothorax, 13 flail chest, and 7 pneumomediastinum. As concomitant injuries, 34 had sternum, 20 clavicle, 13 scapula, 12 vertebra, 9 vertebra+scapula, 5 liver, 2 liver+kidney, 1 kidney, 1 spleen+kidney, and 1 liver+kidney+spleen injuries.

The Rib Fractures Score is used to determine the risk ratio of complications that may develop due to rib fractures, especially in adult patients [10, 11]. In this scoring system, the number of broken ribs, the location of injury and the age are the parameters used. In addition, in the same study, they formed 4 groups with pain scores of 3-6, 7-10, 11-15 and above 15, and found positive results by applying different pain relief methods to each group. As a result, they reported that patients with RFS above 7 pounds should be referred to pain relief units (algology or anesthesia) [12]. In our study, RFS values were higher and statistically significant in the deceased group compared to the surviving patient group, and they correlated with the number of broken ribs, bilateral injury, and patient age.

The Chest Wall Injury Scale is a method that is between 1 and 5 according to the number of fractures, the location of the fracture, the presence or absence of sternum fracture, laceration or avulsion in the soft tissue and skin. This helps to determine the treatment method according to the condition of the injury to the chest wall. In their study with 88 patients, Taylor et al. reported that this scale system is a guide for the decision of surgical intervention, and that an increase in scoring indicates an increase in mortality and morbidity [11]. In our study, CWIS values were higher and statistically significant in the deceased group compared to the surviving patient group.

The Chest Trauma Score is a scoring method based on the patient's age, number of broken ribs, location of the fracture, and lung contusion. Chen et al. reported that the probability of poor outcomes such as complications and mortality can be predicted in patients with thoracic trauma with a CTS above 5 [13]. In our study, CTS values were higher and statistically significant in the deceased group compared to the surviving patient group, and correlated with increased number of broken ribs, bilateral injury, patient age, presence of contusion, presence of hemothorax and pneumothorax.

The Thoracic Trauma Severity Score includes patient age, PaO2/FIO2 ratio, pulmonary contusion, pleural pathology and rib fracture, ranges between 0-25, and is closely related to mortality and morbidity [14]. Elbaih et al. reported that TTSS is a very significant mortality and morbidity scoring system [15]. Although very high values were not observed in our study, they were especially higher and statistically more significant in the group of patients who died compared to the surviving patient group.

The Injury Severity Score is a scoring system that provides a numerical calculation and definition of the total severity of injury in patients with multiple body injuries. It is associated with mortality, morbidity, and length of hospital stay. Using ISS, injuries that are not life-threatening alone have been shown to significantly affect mortality when combined with other organ injuries. If the ISS is greater than 16, major trauma is present. The mortality rate does not increase directly with higher ISS scores, and different injury combinations may yield the same ISS values even though they have different mortality rates. All injuries must be identified when performing the calculation, which is possible only when the patient is discharged. ISS is a calculation method made after the patient is discharged [16]. In our study, ISS values were higher and statistically significant in the group of deceased patients compared to the surviving patient group.

The main approach in the treatment of rib fractures is pain control and breathing exercise. It is essential for elderly patients to be observed in the hospital and a good pain treatment to be provided. Although the treatment of rib fractures is conservative, complications caused by broken ends may require

surgical intervention. In these cases, platinum application is an important method that facilitates stabilization [17]. In our study, 60 patients underwent tube thoracostomy, 10 patients underwent thoracotomy (7 bleeding control+hematoma evacuation, 3 diaphragmatic rupture repair), and 2 patients underwent chest wall reconstruction. Additionally, 10 patients with flail chest were followed up in the intensive care and 3 had fixation+intensive care follow-up.

Conclusion

In trauma patients with isolated thoracic or multiple organ injuries, except ISS, trauma scoring provides preliminary information about mortality and morbidity that may occur. When the number of broken ribs increases, when the rib fracture is accompanied by concomitant intrathoracic pathologies and other organ injuries, rapid and accurate trauma scoring is life-saving. In treatment, patients should be monitored and oxygen saturation, arterial blood pressure, cardiac rhythm and arterial blood gas should be followed. Additionally, pain control and respiratory physiotherapy should be provided. While the primary treatment method in patients with intrathoracic complications is simple tube thoracostomy, larger surgical interventions can be performed in necessary cases despite high mortality. Especially in patients with a high CWIS value, surgery can be performed depending on the condition of the accompanying organ injuries.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: *None*

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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How to cite this article:
Muharrem Cakmak*. Evaluation of scoring methods in trauma patients with rib fractures. Ann Clin Anal Med 2022;13(9):1022-1025*